1983
SOUTHEASTERN SKEENA REGIONAL MOOSE ABUNDANCE AND COMPOSITION SURVEY

by

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INTRODUCTION

In early 1979, the Ministry of Environment produced a Proposed Moose Management Plan for B.C. That document outlined provincial objectives for moose management which included a 25% increase in moose populations. Accordingly, the Proposed Skeena Regional Wildlife Management Plan (van Drimmelen 1984) set as an objective an increase in moose populations in southeastern Skeena Region by 25% from an estimated 16 000 moose within nine Management Units to 20 000 animals. By restructuring the harvest and, therefore, the age and sex structure of the population, recreational days of moose hunting could be expected to double, with a 150% increase in allowable annual kill (van Drimmelen 1984).

Three management prescriptions were outlined:

a) Revise the regulation of moose hunting to protect the prime breeding sectors of the population (especially in the male component), and direct the harvest at teen and calf classes.

b) Monitor the wintering moose population for numbers, age distribution, and sex ratio, beginning with a replicable baseline survey.

c) Identify the highest capability moose ranges, and initiate habitat enhancement on high capability areas with low present use.

Identification of the highest capability winter ranges began in 1980 and continued through 1981, covering almost 18 000 km^2 (7000 mi^2). Revision of moose harvesting began in 1981, although transfer of hunting effort to calves was not initiated. Then in the 1982/83 budget, funds were made available to conduct a replicable inventory. This document reports on that survey, conducted over four days in early 1983.

OBJECTIVES

The inventory was intended to meet three objectives:

1. To test the feasibility of stratified sampling, for estimating moose populations on winter ranges, with strata based on habitat capability;

2. To estimate the size, density, and structure of the moose population within the survey area;

3. To review population trends of moose in the study area and to infer causes of population changes.

SURVEY AREA

The inventory was planned to cover 17 500 km^2 of land on the east side of the Coast Range in northwestern British Columbia (Fig. 1). The western edge

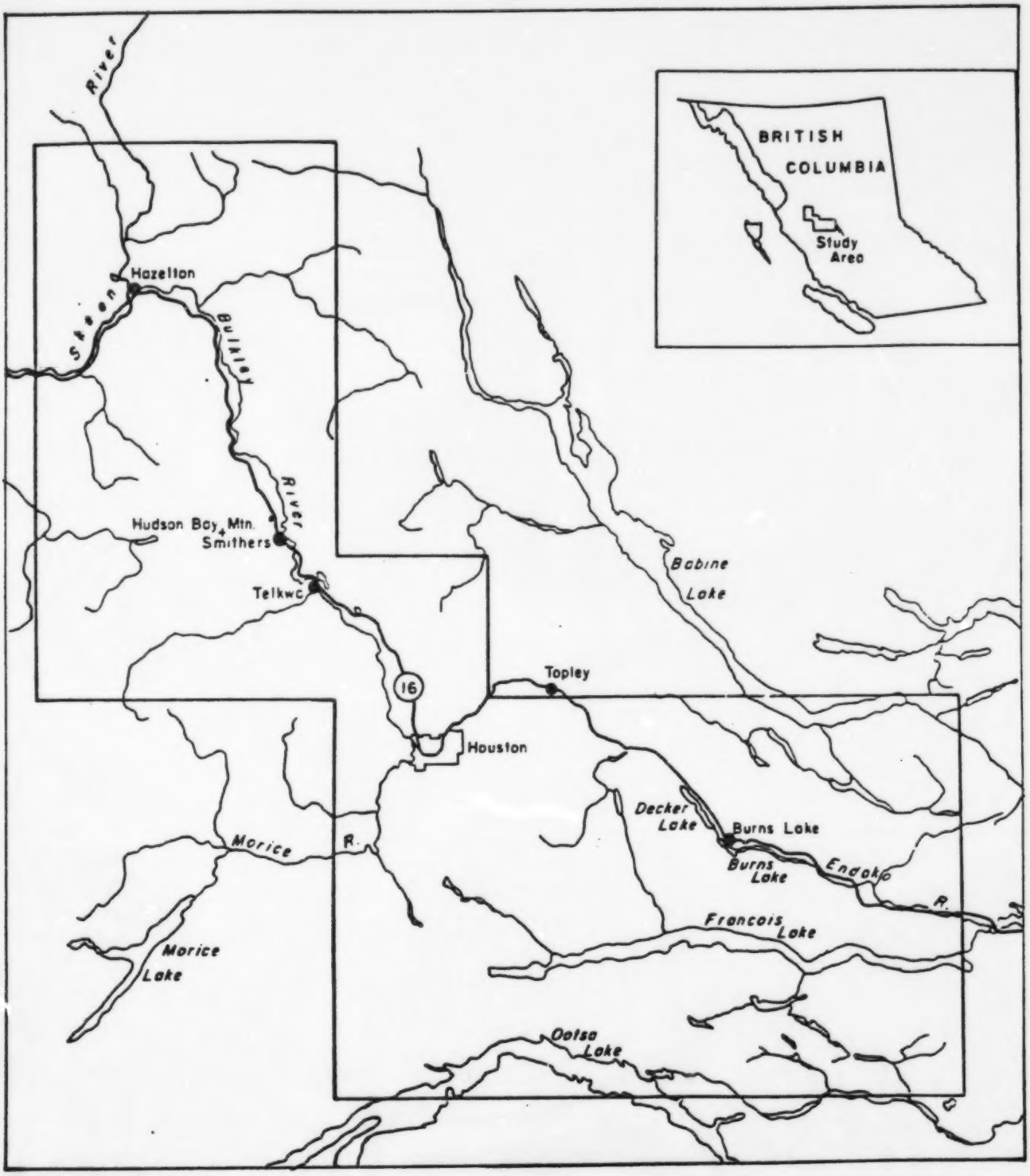

Fig. 1 . Study area.

is very mountainous with alpine tundra and some permanent icefields, reaching elevations of 2400 m above sea level. Eastward, the habitat intergrades to low, rolling interior sub-boreal spruce biogeoclimatic zone forest with higher elevation pockets of Engelmann spruce/subalpine fir (Pojar 1981), and rarely exceeds an elevation of 1400 m.

Within the 17 500 km^2 study area, only 13 000 km^2 constituted the survey area, as fringe areas and lakes were omitted.

It should be noted that this is a resource management project, and not research. For a detailed report on the survey technique, the reader is referred to Gasaway et al. (1981).

The author is deeply indebted to William Gasaway and Stephen Dubois of the Alaska Department of Fish and Game and Samuel Harbo of the Department of Fisheries and Wildlife, University of Alaska. Their 1981 draft manual "Estimating Moose Abundance and Composition" provided excellent guidance for conducting the survey and calculating the result. Whenever we foresaw a problem, those authors had already solved it.

John Thornton and Ian Hatter of the B.C. Ministry of Environment, Wildlife Branch, Victoria, adapted Gasaway's population estimation program to the Apple II Plus computer.

And thanks must go to the twenty-nine volunteers who acted as spotters and navigators. There would have been no way to have five aircraft in the air at a time without them; it would have taken four weeks instead of four days to do without their support.

Tom Parkin of Pathfinder Productions volunteered to assist in photography. Together with Brigitte Rulofs and Randy Semeniuk, he also helped in the time-consuming task of stratification. Ms. Rulofs also assisted in spotting and computer graphics.

And, a final thanks to Shirley Bavalis, Jackie May, Ann May and Darla Cooper for typing, revising, revising and revising this report and to Liz Stanlake who conducted the final polish required for a Working Report.

METHODS

PREPARATION

Stratification

Classified counts had sporadically occurred in portions of the survey area over the previous twenty-five years, but regional wildlife management staff did not feel confident in predicting winter moose distribution based on such sketchy information. With a limited budget (20% less than the initially estimated cost), it was considered inadvisable to invest in extensive flying to stratify the large survey area. Therefore, a stratification method based on habitat parameters alone was developed for this survey, involving capability map, forest cover map, and topographic map interpretation.

1. Capability Mapping

In 1980 and 1981, the Terrestrial Studies Branch of the Ministry of Environment evaluated the capability of the study area to support ungulates. The biophysical classification is based on landform, surficial materials, soils, climate, and vegetation characteristics which are incorporated into "ecologically significant" units of land. For wildlife, such biophysical base maps are supplemented by past animal census data to gain an insight into ungulate distribution and abundance. Areas of land judged to have differences significant to ungulate management are designated as map units on 1:50 000 scale maps.

The capability of the land to support a given ungulate species is based on the long term ability of that land to meet the total needs of the species. It is important to realize that ratings are based on optimum vegetational (successional) stages that can be maintained by intensive habitat management.

Six capability classes are specified, with the four best classes separated into winter and summer capability.

The twenty map sheets which cover the study area were colour-coded into "potential" strata based on each map unit's capability as moose winter range (Table 1).

2. Present Vegetation Correction

As stated previously, capability mapping units do not reflect present vegetative cover. Moose, preferring early plant successional stages, will avoid unsuitable vegetative types (e.g. homogenous coniferous cover) and distribute in areas that show both a capability to support moose and suitable vegetation for cover and food.

Table 1. Potential strata types.

Capability Class (for Moose)	Potential Stratum	Colour Code
1W, 2W	High	Red
3W	Medium	Yellow
4	Low	Green
5, 6	Very Low	Clear

Table 2. Present vegetation correction.

Forest symbol	Reduction in Stratum Level.
Non-Productive Brush Swamp Cottonwood	No reduction
Aspen Birch Mixed Deciduous/Coniferous	Drop 1 stratum
Open Range Pure Coniferous	Drop 2 strata
Cultivated Urban	Drop 3 strata

Therefore, it was necessary to modify the potential strata delineated on the biophysical capability maps to reflect present vegetation. To cover the large study area, we elected to use forest cover maps as indicators of vegetative cover. Forest cover maps, produced at a 1:20 000 scale by the provincial Ministry of Forests, were reduced to 1:50 000 scale and reproduced on transparent mylar overlays.

Each forest type was then colour-coded to reflect our opinion as to its present suitability for moose. Forest types were downgraded (i.e. assigned a lower stratum) on the basis of the criteria shown in Table 2.

For example, any capability Class 1 or Class 2 winter moose range (high density potential) with aspen forest cover would be rated medium (dropped one stratum); any Class 3 capability winter range (medium density potential) overlain with non-productive brush would also receive a medium rating (no stratum reduction).

Delineating Sample Units

A sample unit is "the smallest delineated portion of the survey area that has a probability of being selected and searched in its entirety for moose" (Gasaway et al. 1981). Sample units usually ranged from 30- to 40 km^2 in area, but were not drawn smaller than 15 km^2 or larger than 55 km^2. The boundaries of sample units were to be easily recognizable from the air, so sample units were delineated on 1:40 000 topographic maps. Generally, creeks, rivers, roads, or elevation contours were used as boundaries, although straight lines between peaks, lakes, or distinctive bends in rivers were occasionally used. Sample unit boundaries avoided areas which, on the stratification-coded forest cover maps, showed a probability of high or moderate moose density.

As a final consideration, sample unit boundaries were drawn to encompass areas having similar moose distribution. With the use of a light table, it was possible to draw sample units on a topographic map (which showed those features used as unit boundaries) overlying the colour-coded forest cover maps showing expected moose distribution.

Each sample unit was measured for area and numbered. Three hundred and fifty-five sample units were delineated covering 13 000 km^2.

Map Stratification

Based upon the colour-coded forest cover maps, it was possible to stratify each sample unit as to overall expected moose density. Originally, it was planned to produce four strata; however, it was impossible to differentiate objectively between the higher strata from the maps alone. Some areas were obviously not suitable for winter range and fit a "Very Low" stratum; other sample units were expected to have a few moose ("low" stratum); but a third category of sample unit was not readily subdividable - that showing moderate- to high- expected density. Accordingly, only three strata were established - high, low, and very low.

On 1983 January 20, a helicopter flight was taken in association with other work to assess the map stratification. Twelve sample units were

investigated and rated subjectively as showing signs (e.g. tracks) of no moose, few moose, or many moose. That stratification was compared to the earlier map-based stratification, with the result that 8 of 12 sample units were judged to have been correctly stratified. Incorrect stratification was due to over-rating the more marginal "high-density" sample units in three cases. The fourth error was due to logging that had occurred since the forest cover maps were produced (i.e. vegetative cover information was out of date.)

As a result of the stratification verification flight, all 81 "high" -rated sample units were re-examined on the maps, and 17 (21%) were down-graded to the low category.

Selecting Sample Units

From a table of random numbers, 60 sample unit numbers were selected without replacement of units. As per Gasaway et al. (1981), five sample units in each stratum were selected in order of convenience, for initial survey. After five units were surveyed, subsequent plots were inventoried in the order in which they were selected from the random number table.

As recommended by Gasaway, twenty plots with area of 5- to 8 km^2 were located within high density sample units to be searched by helicopter to calculate a sightability correction factor (SCF) for the fixed-wing count. Again, boundaries were set to be recognizable from the air, and the quadrant which would contain a plot in each sample unit was randomly chosen.

Training of Survey Crews

On 1984 February 7, twenty-nine volunteer spotters were taken for 30-40 minute training flights to establish their search image. As the aircraft (Cessna 185) flew at an approximate altitude of 200 m and each searcher was to cover a 200 m strip, spotters were trained to look no higher than a 45° angle downward from each side of the aircraft, so as to cover (with two spotters) 400 m of width per transit. Instructions to volunteers are included in Appendix A. During training flights, the spotters also became familiar with the recording forms (Appendix A).

SURVEY METHODS AND SEARCH EFFORT

Fixed-Wing Survey (Low Intensity Search)

Search effort for the fixed-wing aircraft was set at 1.8 minutes per km^2 (4.5 min/mi^2), so that a search time was designated per sample unit based on the area of each unit. Flight lines were set at 0.4 km (1/4 mi) intervals in a direction such that transects were as short as possible. At an airspeed of 100-120 km/h (60-70 mph) with approximately a 45° bank turn, the entire sample unit was covered within minutes of the required time. Pilots were able to put the aircraft on transect with little direction from the navigator.

Crew involved four people (including the pilot). Their duties were:

Navigator
- in front seat. Ensured that pilot knew sample unit boundaries.
- marked transects on 1:50 000 scale map.
- marked location of each moose observed by the spotters, so that counting the same moose twice could be minimized.
- assisted the starboard spotter in observing moose.

Spotters
- on each side, in rear seats.
- watched for moose in a 200 m search strip.
- filled out data forms, recording:
  - sample unit number
  - date
  - start and stop time of search
  - weather
  - snow conditions
  - for each moose aggregation, recorded number of moose, posture (standing or lying down), and vegetation type the moose were found in.

Pilot
- maintained altitude near 200 m.
- maintained airspeed as slow as was considered safe (usually 100-120 km/h (60-70 mph)).
- kept transects parallel using instrumentation.
- remained aware of sample unit boundaries.
- assisted port spotter in observing moose.

Helicopter Survey (High Intensity Search)

As was noted briefly under "Selecting Sample Units", twenty plots with areas ranging from 5- to 8 km^2 were delineated within twenty high density stratum sample units. Purposes of this survey were:

a) to provide classification of moose by sex and age (calf vs. adult); and

b) to determine sightability, defined as the percentage of moose present which were seen during the fixed-wing survey.

The helicopter survey began within ten minutes of coverage of the plot with fixed wing. Search effort was set at 4.5 minutes per km^2 (12 min/mi^2). This search pattern did not involve transects, but involved a series of small circles with frequency of turning and air speed varying to account for vegetational canopy height and vegetation density.

Locations of moose observed were mapped on 1:50 000 scale maps, and sexed by the presence or absence of the white vulval patch.

CALCULATIONS

Initial calculations were identical to those presented by Gasaway et al. (1981). Gasaway included programming for a programmable calculator, but the

Ministry of Environment Biometrics Section prepared a comparable program for an Apple II Plus computer. This program was updated in 1984 to calculate variance of the SCF and optimal allocation. For each of three strata, a population estimate and its variance were calculated, and the strata estimates were summed to arrive at a total for the survey area. A 90% confidence interval was specified, and upper and lower confidence intervals were produced. Two multipliers were used to account for missed moose:

a) a ratio of moose seen from helicopter on the 20 high intensity survey plots to moose seen on the same area from the fixed-wing survey (SCF_o); and

b) a standard correction factor (SCFc) for moose missed during the intensive survey. Gasaway et al. (1981) recommended 1.09 for intensive surveys with fixed-wing aircraft (Supercubs) for surveys in February, March, or April. As this figure was developed using radio-collared moose, this study could not modify such a factor to suit our survey conditions, so the recommended figure was utilized.

In an effort to minimize the range of the confidence interval, the data were considered for possible data transformations by biometrics staff in Victoria.

RESULTS

POPULATION ESTIMATION

Within the 13 000 km^2 survey area, there were an estimated 6385 moose. The 90% confidence interval calculated as per Gasaway's original program was 17% of the estimate.

However, at the time of his 1981 report, Gasaway's calculations accounted only for variation between sample units; it did not consider variation of the sightability of moose. As shown in Table 3, this survey encountered high variability in sightability, with an average of 2.35 more moose visible from the helicopter than from the fixed-wing.

Gasaway et al. (1984) developed the statistical treatment to incorporate that second source of variance. Under this improved system, the proper 90% confidence interval came to 6385 ± 2245, or 35% of the estimate (Appendix C). Fully half of the width of the interval is due to variation in observability.

In conclusion, the study area is estimated, with 90% confidence, to contain between 4140 and 8630 moose.

Twenty-two sample units in the high density stratum, ten in the low density stratum, and six in the very low stratum were inventoried. Variance was very high in the high density stratum (44 550 as opposed to 15 530 and 2974 for the low and very low areas, respectively). Although optimal allocation formulas (Gasaway et al. 1984) were not available at the time of the survey, it was apparent that more sampling was required in the high density strata. With optimal allocation, sampling would have been directed to 3 low, 9 medium, and 26 high density areas. However, after completing 38 sample units, funding was exhausted.

Table 4 summarizes the area of each sample unit and the number of moose observed from the fixed-wing aircraft.

There were 115 moose observed from the fixed-wing in the 20 high-intensity survey plots as opposed to 266 observed in the same areas from helicopter, for a correction factor of 2.35 (Table 4). Incorporating a correction factor of 1.09 for moose missed in the high-intensity (helicopter) survey resulted in an overall sightability correction factor of 2.52 moose actually assumed to be present for every moose counted during the fixed-wing (low-intensity) survey.

SEX RATIO

There were 266 moose classified in the high density stratum. Non-calves showed a sex ratio of 36 bulls:100 cows, whereas calves exhibited a male-dominant ratio of 126 males:100 females (Table 5). However, the white

Table 3. Moose counts in high-intensity survey plots (area = 5-8 km^2)

Plot No.	Low Intensity (fixed-wing count)	High-Intensity (Helicopter count)
1	3	2
70	0	0
103	8	12
143	3	9
151	1	3
163	1	16
166	22	49
199	18	48
203	28	35
222	0	24
239	3	5
243	9	24
274	2	3
279	6	10
288	1	1
291	6	13
310	1	4
331	1	3
333	0	5
TOTAL	113	266

Ratio of moose seen in high- versus low-intensity searches = 2.35

Table 4. Survey results - low-intensity (fixed-wing) survey.

Plot No.	Area (km^2)	Moose Count
HIGH STRATUM		
1	34	9
70	39	9
103	36	25
105	49	57
106	28	19
143	41	10
151	36	24
163	39	16
166	39	53
168	47	23
174	44	46
199	36	70
222	23	23
239	31	10
243	23	13
274	34	5
279	34	18
288	39	26
291	18	17
310	26	6
331	39	9
333	28	5
LOW STRATUM		
32	36	7
33	41	6
39	31	5
44	39	6
53	26	10
59	44	1
69	39	3
78	34	12
245	26	1
252	39	5
VERY LOW STRATUM		
3	54	1
55	39	0
95	44	0
97	28	1
140	62	0
343	31	2

Table 5. Moose classification - 1983 inventory

Plot #	AF	AM	UA	MC	FC	UC	TOTAL
1	2	-	-	-	-	-	2
70	-	-	-	-	-	-	0
103	7	2	1	1	1	-	12
143	6	1	1	-	1	-	9
151	-	3	-	-	-	-	3
163	7	5	1	-	3	-	16
166	22	12	2	5	3	5	49
199	25	15	-	3	5	-	48
203	18	3	6	5	2	1	35
222	14	3	-	3	2	2	24
239	4	1	-	-	-	-	5
243	13	4	-	6	1	-	24
274	3	-	-	-	-	-	3
279	5	1	-	3	1	-	10
288	-	1	-	-	-	-	1
291	9	-	-	1	3	-	13
310	2	-	-	-	1	1	4
331	2	-	-	1	-	-	3
333	4	-	-	1	-	-	5
TOTAL	143	51	11	29	23	9	266

Male:Female:Calf ratio = 36:100:43

AF = Adult Female (i.e. - older than 1 year)
AM = Adult Male
UA = Unclassified Adult
MC = Male Calf
FC = Female Calf
UC = Unclassified Calf

vulval patch in calves may not be a reliable indicator, so the calf sex ratio was not considered in further analysis of the results.

RECRUITMENT

There were 43 calves per 100 female non-calves (Table 5), or 23% of the moose in the high density stratum were calves.

COSTS

A total of $5,200 in helicopter charters plus $10,950 of fixed-wing charters were required to achieve the results of this survey, for a total cost of $16,150. Additionally, 75 man-days were required to conduct the survey, plus another 70 man-days for preparation (map work, etc.). At a cost of $90/day, labour cost equals $13,050. Total cost, therefore, approached $30,000, or $2.25/km^2 ($5.80/mi^2).

DISCUSSION

POPULATION ESTIMATION

For management purposes, it was desirable to extrapolate the findings of this survey to nine Wildlife Management Units (M.U.'s) which included and surrounded the survey area. Those M.U.'s form an area with good public access, and possible overharvest of bull moose had been suspected since 1980 (van Drimmelen, 1984). In response to that possible overkill, restrictive regulations came into effect in 1981. To set allowable annual harvest limits, a population estimate per M.U. was required, and in the absence of a moose abundance survey, the "Omineca system" (0.42 moose/km^2 of land area below 1200 m - 1.1 moose/mi^2) was used (K. Child, pers. comm.), yielding an overall population estimate of 13 250 moose within 31 200 km^2 of land area. Given the abundance estimate arising from this survey for 13 000 km^2 of land which formed the core of that larger area, extrapolation was possible.

By reviewing moose distribution observed during the survey, it was noted that the 900 m contour generally defined the average upper elevational limit of moose. Variation due to aspect in particular was apparent, but was thought to equilibrate over the entire area.

When the estimated 6385 moose are related to the 6900 km^2 of land area below 900 m in the study area, a density of 0.88 moose per km^2 (2.28 moose/mi^2) is established. Within the 31 200 km^2 comprising the M.U.'s of concern, the area below 900 m was measured and an estimated winter population per unit was calculated, as shown in Table 6; a population estimate of 13 910 moose was derived.

The above estimate is 5% above the previous "planimetric" estimate of 13 250 moose and within the 35% confidence interval of our original study area population estimate. Accordingly, it can be inferred that the measured population estimate is not significantly different from our previous estimate.

Until the recent initiation of habitat enhancement, the only moose management technique practised in Skeena region had been the regulation of human predation. Such regulation has involved setting harvest limits and directing the harvest effort at particular segments of the population, and applies almost exclusively to the late summer and autumn period (September-November). Accordingly, for this survey to have management application, autumn populations by M.U. must be estimated. A brief radio-telemetry study in 1981 (Marshall 1982) demonstrated that moose cross M.U. boundaries during their seasonal migrations. Specifically, whereas the western portion of southeastern Skeena region contains much area suitable for calving and summer range, deep snow conditions prevail in winter. Therefore, moose summering in the western and southern-most portions of the region are driven into the eastern M.U.'s for the winter period.

In an attempt to predict the autumn moose distribution while making allowance for the fact that moose favour mid-slope and valley-bottom habitat

Table 6. Estimated winter moose populations by M.U.

M.U.	Land area below 900 m (km^2)[a]	Estimated winter moose population[b]
6-1	440	390
6-2	440	390
6-4	2330	2050
6-5	375	330
6-6	1310	1150
6-7	1140	1000
6-8	3625	3190
6-9	3400	2990
6-17B	2750	2420
	TOTAL POPULATION =	13910

a - Measured by planimeter

b - Area x 0.88 moose/km^2

types over alpine, we arbitrarily set 1200 m to approximate the upper elevational autumn distribution limit of moose. Redistributing the estimated 13 910 moose by the land area below 1200 m in each M.U. produced estimated fall populations that differed considerably by M.U. from the winter populations, as shown in Table 7.

By using the traditional Hunter Sample data base one can make inferences as to past gross population trends. However, data on resident harvest are difficult to analyze over long time periods due to changes in administrative boundaries.

To obtain a pattern in annual moose kill, number of hunters, and percentage of moose hunters who were successful in killing a moose, two analyses of Hunter Sample Data were attempted; one short-term (1976-1981), and one longer term (1967-1981).

It is possible to go back with precision only as far as the 1975-1976 season within the survey area. Previous to that date, the nine management units concerned formed portions of two large Management Areas (#22, #25). In the nine Management Units for which population estimates were made, Figure 2 shows the pattern since 1976. The drop in number of hunters in 1981 and 1982 is a result of implementation of Limited Entry hunting regulation. No obvious pattern in hunter success is apparent.

If, however, one examines the data over a longer period, a pattern is apparent. In order to utilize data going back to 1967, one must look at Management Areas 22 and 25, which encompassed the study area (M.U.'s 6-1, 6-2, 6-4 to 6-10, 6-15 to 6-18). Figure 3 shows that those M.A.'s experienced a marked decline in number of hunters, from a pre-1973 level of 10 000-14 000 down to a post-1976 level of 8000. (To show that the drop is not an aberration due to the 1975 change in administrative boundaries, Figures 3a and 3b show the patterns in the individual M.A.'s which are combined in Figure 3. Note that M.A. 25 (Fig. 3b) shows an insignificant decline in number of hunters). Moose kill dropped at a somewhat faster rate, so that hunter success (percent of moose hunters who shot a moose) dropped from 35 - 45% before 1973 to 25% since 1976 in M.A.'s 22 and 25 combined (Fig. 4).

Given that a 34% drop in number of hunters over fourteen years has been accompanied by a 38% decline in hunter success (rather than an increase), this combination of trends suggests strongly that fewer moose are present now in the study area than were there in the late 1960's. (This conclusion ignores the patterns of hunter access development, as such development is not readily collatable).

We assumed, for lack of a more precise estimate, that a 38% decline in success despite a strong decrease in the number of hunters represented a corresponding reduction in the moose population, and so hypothesized that in 1967 the study area contained 22 000 moose. For analytical purposes, we assumed a simple linear reduction in the moose population between 1967 and 1980 (Fig. 5).

The kill in the study area has averaged 91% of the total kill in M.A.'s 22 and 25 since 1976. Correcting the estimated moose kill in those M.A.'s to

Table 7. Estimated winter and autumn moose populations.

M.U.	Winter Population	Autumn Population
6-1	390	1365
6-2	390	900
6-4	2050	2535
6-5	330	360
6-6	1150	740
6-7	1000	890
6-8	3190	2460
6-9	2990	2905
6-17B	2420	1755
TOTAL	13 910	13 910

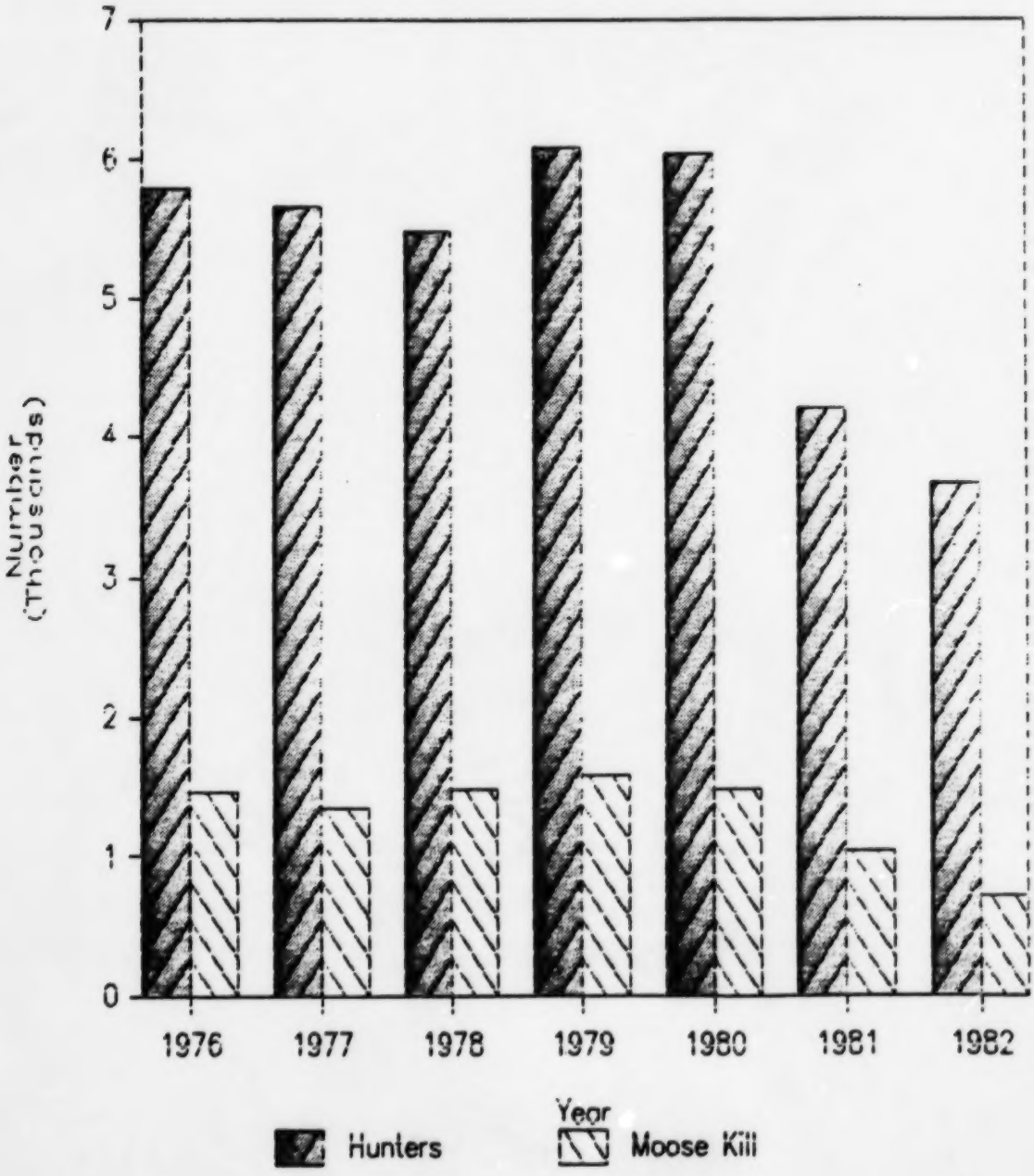

Fig. 2. Short-term hunter/harvest trend, SE Skeena Region.

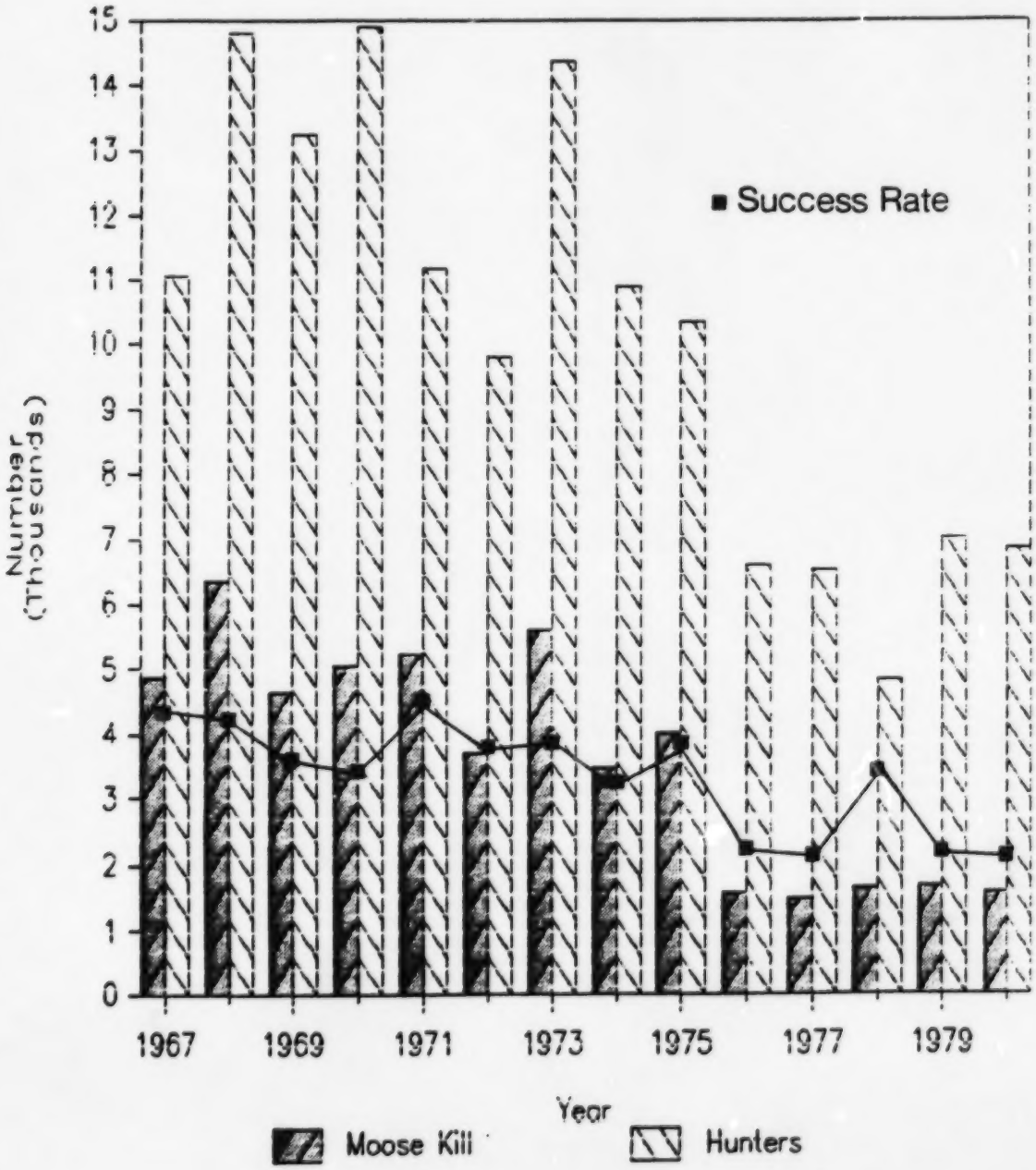

Fig. 3. Long-term hunter/harvest trend. M.A.'s 22 and 25.
(% success rate has been multiplied by 100 to fit on graph)

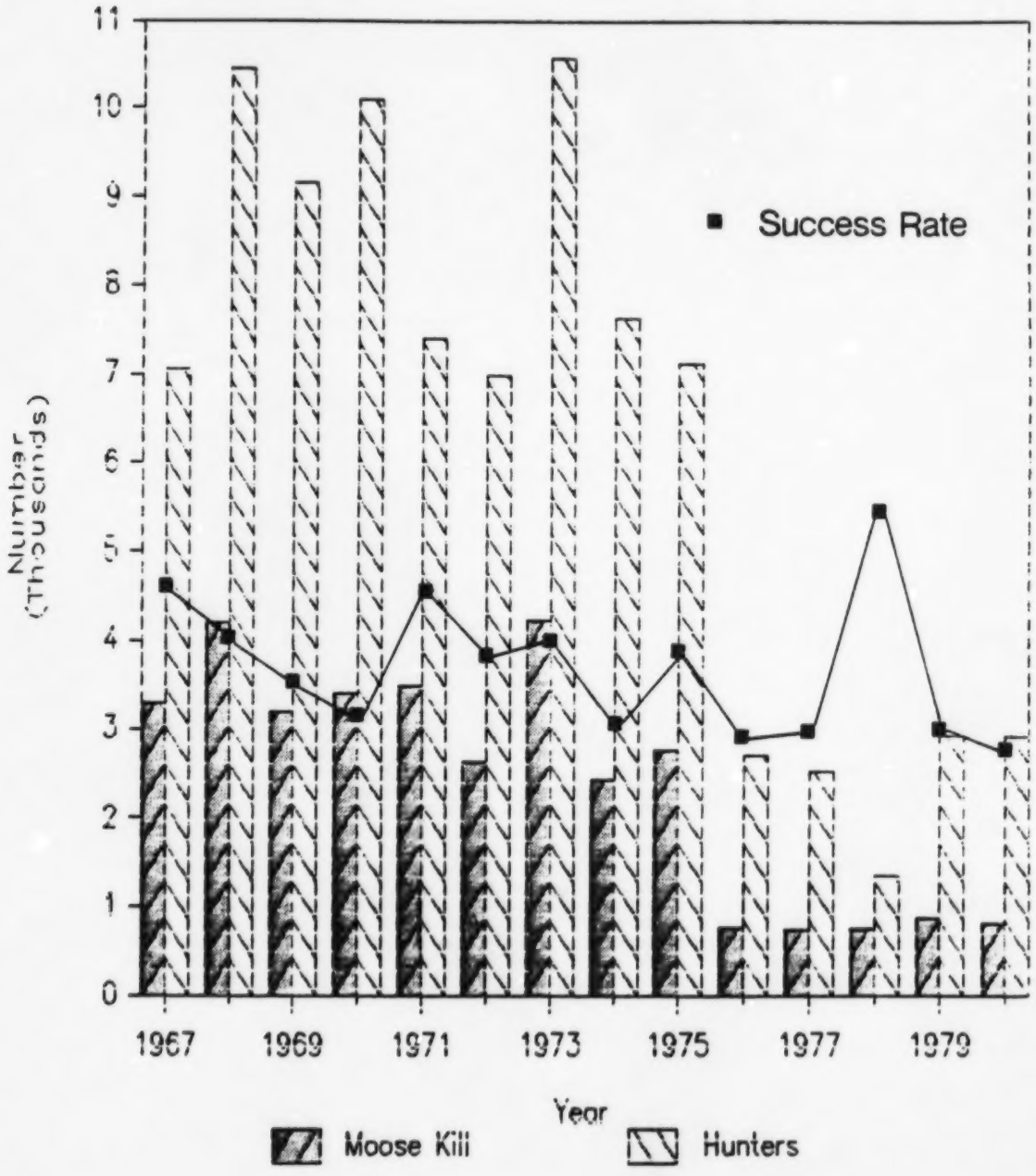

Fig. 3a. Components of long-term trend – resident hunt, M.A. 22.

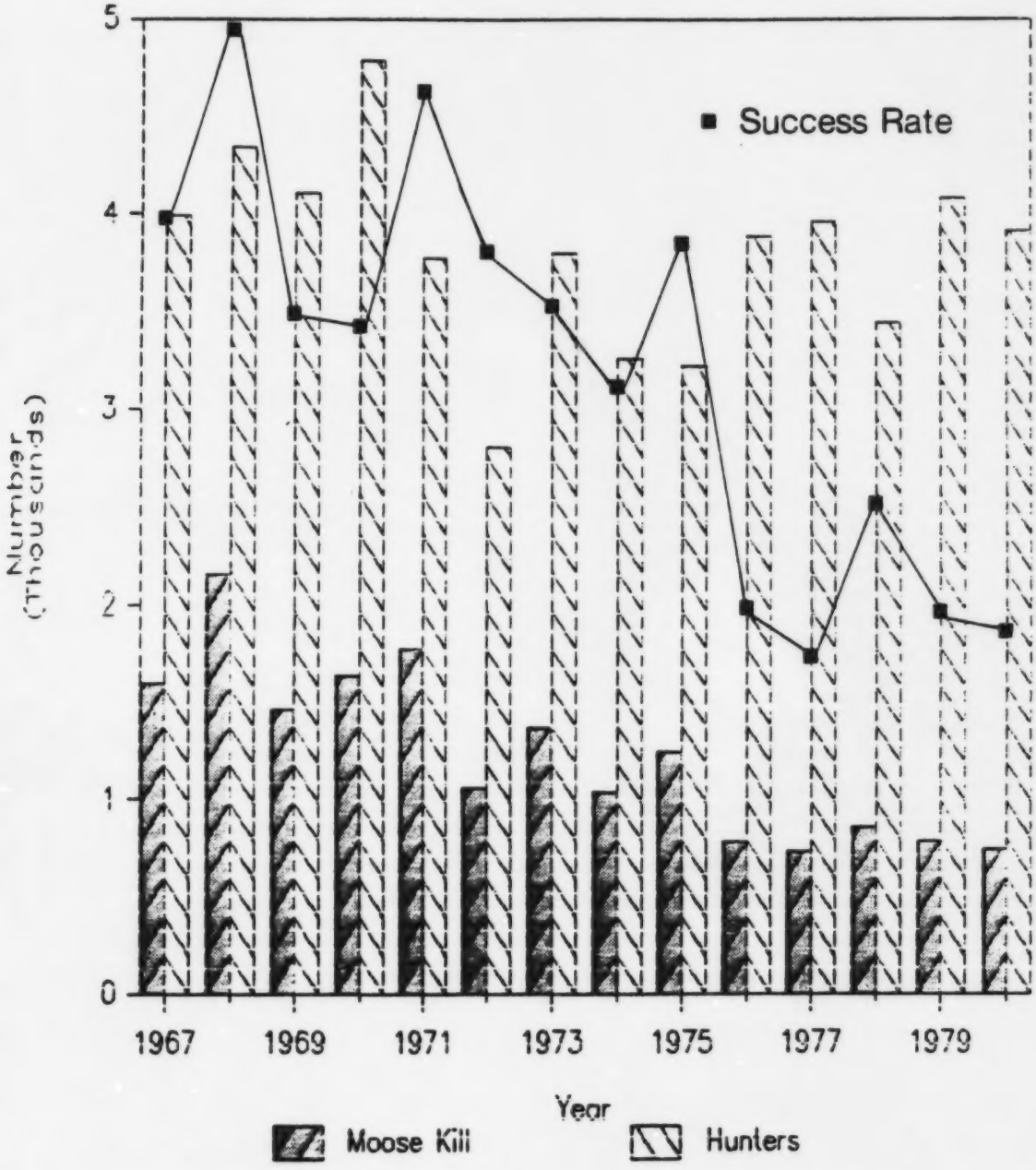

Fig. 3b. Components of long-term trend – resident hunt, M.A. 25.

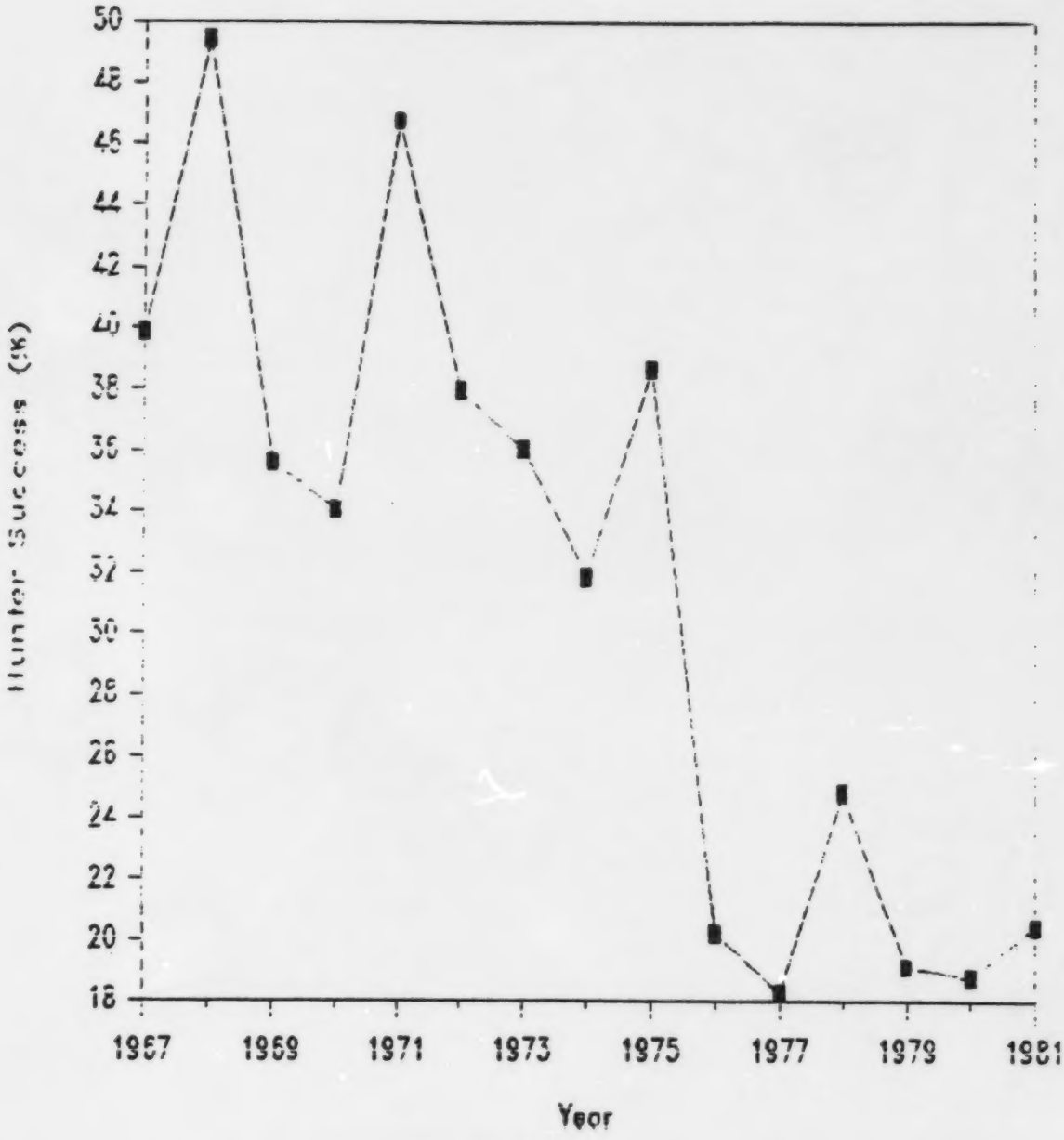

Fig.4. Decline in hunter success rate (M.A.'s 22, 25).

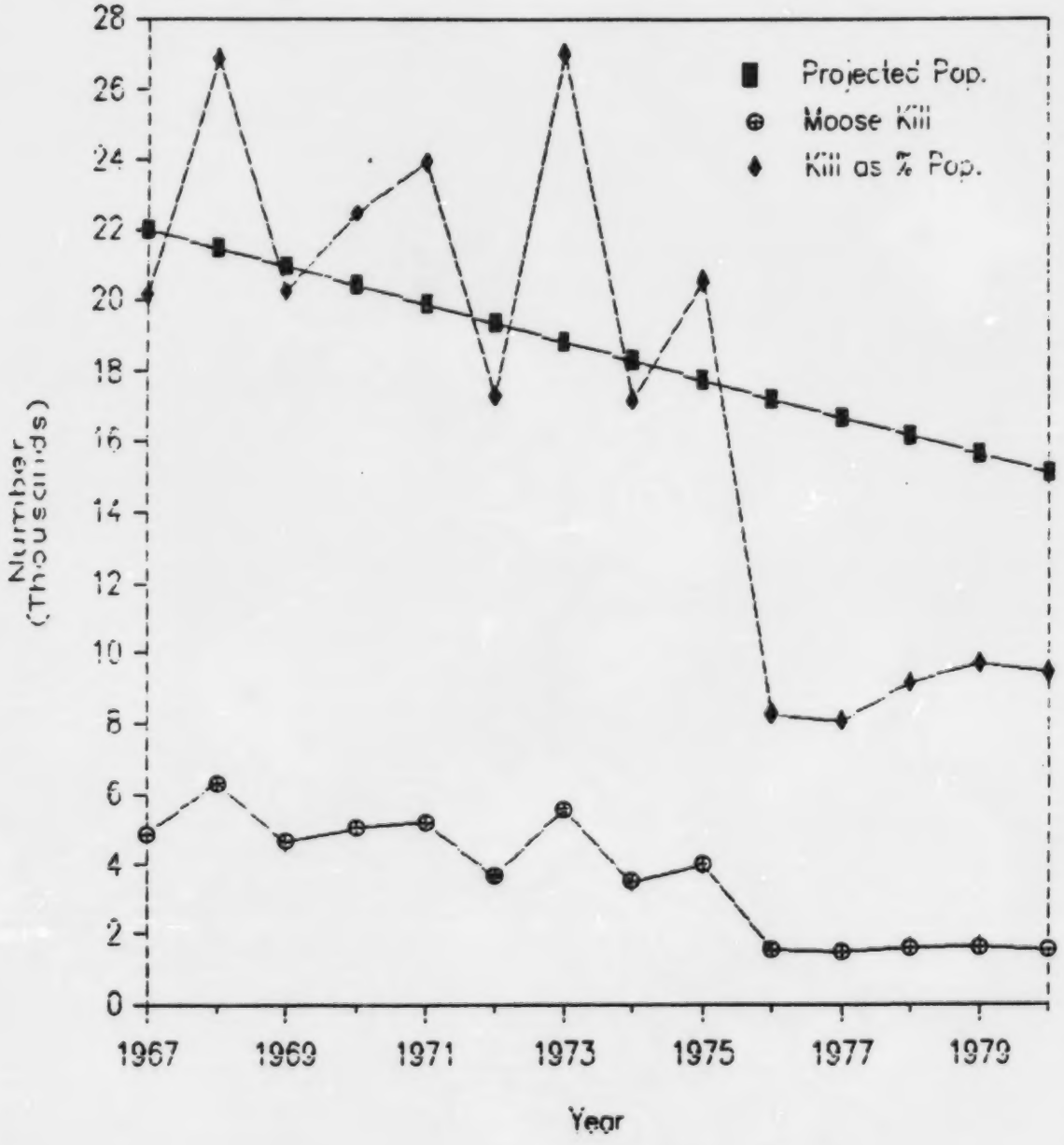

Fig. 5. Proportion of estimated moose population harvested each year, 1967 – 1980.

reflect that, one can examine the proportion of the estimated moose population which was harvested each year. (Fig. 5).

SEX RATIO

The 1983 bull:cow ratio of 36:100 (assuming it was representative of the entire survey area) is one of the lowest ratios encountered in the study area since surveys begain in 1956 (Table 8). However, ratios reported before 1968 are not considered reliable because of the difficulty of sexing antlerless moose from fixed-wing aircraft. To verify this difference between fixed-wing and helicopter surveys, a Mann-Whitney test was performed. The mean bull:cow ratio using fixed-wing aircraft (1956-1966) was significantly less than with helicopter (1968-1983) ($z = -2.17$, $p = .03$).

Using the more reliable 1968 to 1983 data (Fig. 6), there was a significant correlation between the bull:cow ratio and years ($r_s = -.73$, $p = .004$). This decline was significant ($t = -4.34$, $p = .001$) and the data was fitted to a regression line ($r^2 = .631$; Fig. 7; I. Hatter, pers. comm.).

The decline in the bull:cow ratio corroborated the theory of past overharvest of moose (described in a previous section), as past harvests focused primarily on bulls.

RECRUITMENT

The 1983 calf:cow ratio of 43:100 (assuming it is representative of the entire survey area) is similar to the 19-year mean of 40 (Table 8).

Trends in calf:cow ratios were compared to trends in winter severity (calculated from March 1st snowdepths at Fort St. James, 65 km east of the study area), length of cow season, and ratio of bulls:100 cows. The data are shown in Table 9. The Spearman Rank Correlation Coefficient was used to measure correlation with significance ($p = .05$) determined from a table of critical values (Hayslett 1968). Coefficient values and critical values are shown in Table 10.

No significant correlations were found between the calf:cow ratio and either winter severity or the length of the hunting season on cows. These results suggest that calf survival is not strongly influenced by winter snow depth or cow seasons or that other factors exert greater influence.

Calf:cow ratios correlated significantly (but weakly) with concurrent bull:cow ratios, but not to bull:cow ratios from the year immediately preceding or following the survey. No cause for such a correlation is suggested.

USE OF CLASSIFIED COUNT DATA - A CAUTIONARY NOTE

The preceding sections ("Sex Ratio" and "Recruitment") relied almost exclusively on historical classified count data. It should be kept in mind that it has been this region's experience that classified count data are to be treated with extreme caution.

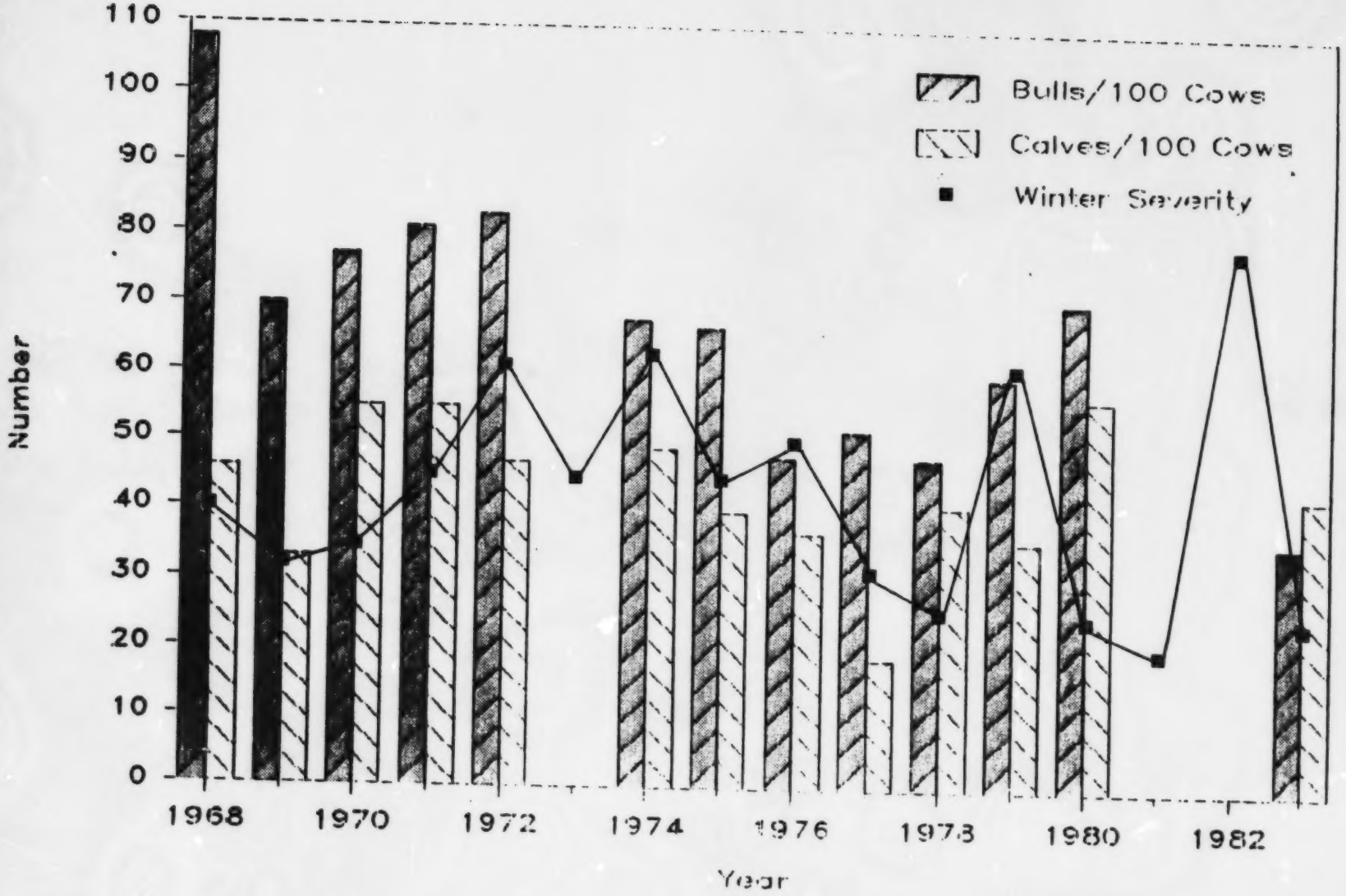

Fig. 6. Relationships among bull ratio, calf ratio, and maximum snow depth.

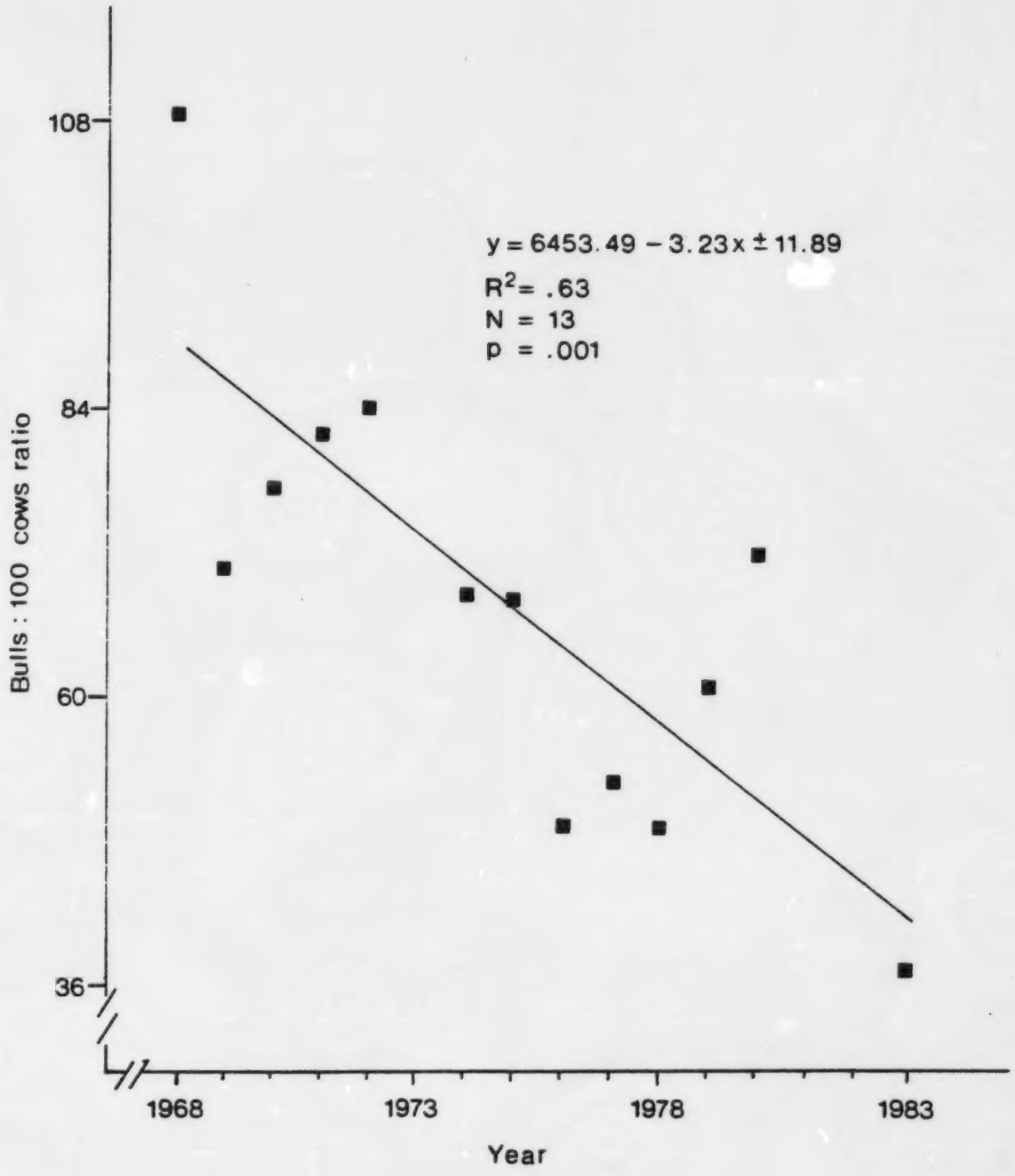

Fig. 7. Regression line to best fit bull : cow ratio decline.

Table 8. Winter moose classification data, 1956-1983.

Date	Aircraft [a]	Total	Calves	Cows	Bulls	Bulls/ 100 Cows	Calves/ 100 cows
Dec. 1956	F	842	141	437	264	60	32
Jan. 1957	F	439	90	266	173	65	33
1958	No Survey						
Jan. 1959	F	358	143	? [b]	?	?	?
Jan. 1960	F	700	?	?	?	?	?
Jan. 1961	F	483	152	324	159	49	47
Jan. 1962	F	699	112	437	262	60	26
Jan. 1963	F	326	55(?)	52	17	33	?
Jan. 1964	F	685	152	514	171	33	30
Dec. 1964	F	506	121	356	150	42	34
Jan. 1966	F	365	100	233	132	57	43
1967	No Survey						
Jan. 1968	H	663	102	223	240	108	46
Jan. 1969	H	255	79	150	105	70	33
Jan. 1970	H	286	76	162	124	77	55
Feb. 1971	H	403	122	223	180	81	55
Dec. 1971	H	604	154	330	274	83	47
1973	No Survey						
Jan. 1974	H	575	151	307	208	68	49
Jan. 1975	H	452	107	268	184	67	40
Dec. 1975	H	534	123	357	177	48	37
Feb. 1977	H	643	79	423	220	52	19
Feb. 1978	H	453	81	197	94	48	41
Feb. 1979	H	181	32	90	54	60	36
Mar. 1980	H	580	112	197	140	71	57
1981	No Survey						
1982	No Survey						
			19-YEAR MEAN			62	40
Mar. 1983	H	266	61	143	51	36	43

[a] F - fixed-wing; H - helicopter

[b] Classification not known

Table 9. Parameters tested for correlation with calf:cow ratio trends.

Year	Calf:100 cows Ratio	Winter Severity [a]	Cow Season (days)	Bull:100 cows Ratio
1968	46	39	72	108
1969	33	32	54	70
1970	55	34	26	77
1971	55	46	30	81
1972	47	61	49	83
1973	Not Surveyed			
1974	49	62	9	68
1975	40	43	23	67
1976	37	49	23	48
1977	19	31	23	52
1978	41	25	23	48
1979	36	61	23	60
1980	57	24	23	71
1981	Not Surveyed			
1982	Not Surveyed			
1983	43	6	0	36

[a] Calculated from March 1 snowdepths at Fort St. James

Table 10. Spearman Rank Correlation Coefficient values.

Test (Calf:cow ratio vs.)	Coeff. Value	N	Crit. Value (p=.05)	Sig. Corr.
Previous winter's severity	0.036	10	0.567	No
Current winter's severity	0.025	13	0.539	No
Length of previous cow season	0.124	10	0.681	No
Length of current cow season	0.070	13	0.680	No
Previous year's bull:cow ratio	0.267	10	0.460	No
Current year's bull:cow ratio	0.554	13	0.048	Yes
Subsequent year's bull:cow ratio	0.334	9	0.383	No

On 1979 February 26 and March 2, D. Hatler replicated a classified count in the lower Nadina River area. Quotations from his flight report follow. His data are shown in Table 11.

"Despite a remarkable similarity in total count for the two days, there were significant differences in composition. Temperature, wind and light conditions were similar for the two days, both surveys were about mid-day, the same aircraft and pilot were used, and a similar search pattern was worked. All classification designations, based on presence or absence of the white vulva patch, were confirmed by myself. I am confident that the discrepancies between the two sets of data did not arise from errors in classification on either day. Rather, there were simply more females and fewer males in the Nadina River valley bottom on the first flight; vegetation in this area is such that few which are present in the valley are missed."

"The only possible explanation is that animals were in the timbered areas (adjacent to the valley) on both days and...it appears that the missing subsample was heavily biased on both days."

In his conclusion, Hatler stated:

"Classification counts of moose in winter concentration areas, our sole moose inventory technique at present, do not provide useful density information and may not provide accurate composition information."

The impact of inaccuracies in any years' composition data on the trends referred to in previous sections cannot be evaluated without considerable research with replication counts. However, caution in interpretation is suggested.

Table 11. Replication classified count data, 1979.

	Adult Males		Adult Females		Calves		Total
	Number	%	Number	%	Number	%	
February 26	54	(31)	90	(51)	32	(18)	176
March 2	86	(46)	71	(38)	32	(17)	189

CONCLUSIONS

REGARDING THE 1983 MOOSE INVENTORY

1. Stratification by biophysical ungulate capability and forest cover were adequate to produce three distinct strata. A fourth stratum, subdividing the "high-density" category, is recommended to decrease variance. Fixed-wing reconnaissance over subunits with a preliminary "high-density" rating is recommended for subdivision.

2. The survey method recommended by Gasaway et al. is well suited to the central interior of B.C., although the extreme variation in sightability between intensive and extensive surveys must be reduced. Stratification of habitat by expected sightability may be warranted, and should be examined.

3. A helicopter is recommended for high-intensity searching, both to ensure thorough search and to obtain good classified count data.

4. Within the 13 000 km study area, a population estimate of 6385+ 2245 moose was derived (90% confidence interval), with half of the confidence interval width due to sightability variance.

5. An average of 2.35 moose were observed on the ground for every moose censused by fixed-wing aircraft during the low intensity searching.

6. A sex ratio of 36 bulls:100 cows (n = 212) was found, the third lowest ratio recorded in 20 years.

7. There were 43 calves per 100 cows, similar to the 19-year mean of 40.

8. Cost of the survey in aircraft rentals was \$16,150, or \$1.24/km^2. Including labour costs, the total cost would approach \$30,000, or \$2.25/km^2 (\$5.80/mi^2).

REGARDING TRENDS IN THE MOOSE POPULATION SINCE 1956 IN SOUTHEASTERN SKEENA REGION

1. Extrapolating the survey results to the 31 200 km^2 area of management concern produces a wintering moose population estimate by Management Unit of 13 910. This is not significantly more than the previous estimate, made only on the basis of topography, of 13 250 moose.

2. For harvest regulation, it was required to estimate the distribution of the 13 910 moose during the autumn. Considerable difference in population estimates per Management Unit resulted.

3. A major and rapid decline in the number of hunters and hunter success occurred in the early 1970's, so that by 1975, the area showed a 34% drop

in number of hunters and a 38% decline in hunter success as compared to late 1960's levels.

4. A concurrent decline in number of hunters and hunter success implies that fewer moose are present in the study area now than there were a decade ago.

5. A significant decline from 85:100 to 36:100 in the ratio of bulls:cows occurred between 1968 and 1983.

6. The decline in numbers of hunters, hunter success, and bull:cow ratio from 1967 to 1980 suggests that harvests were likely excessive and may have caused a reduction in moose numbers. A reduction to approximately 60% of 1967 populations is theorized.

MANAGEMENT RECOMMENDATIONS

1. Restrictions on the recreational harvest of moose, initiated in 1981, should be maintained such that annual harvest is less than 10% of the estimated fall population until hunter success again reaches 35%.

2. A re-inventory should occur in approximately 1988, with the timing dependent on:

   a. similar winter conditions

   b. intervening recruitment rates as measured by harvest statistics and biennial classified counts.

3. Classified counts should continue biennially in the Smithers/Lakes District areas. Emphasis should be on replicating surveys to obtain more information on the reliability of this historical "inventory" technique. Population trends should be predicted, and subsequently tested by the 1988 inventory.

4. The management objective of 20 000 moose (a 30% increase over present populations) appears realistic.

5. In view of high calf recruitment, predation may not be a limiting factor in the study area. Predator control is not considered essential to meet moose production objectives.

6. In view of continued low bull:cow ratios, protection of the male segment of the population from high harvest is recommended to continue.

7. Periodic harvesting of cow moose is not warranted in the context of a management strategy of increased herd size.

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APPENDIX A

Instructions to Volunteers
Data Recording Form

Introduction

The moose survey covers 12,000 square miles. However, only portions of the survey area will be flown; statistics will then be used to come up with overall population estimates.

In a nutshell, the technique is as follows:

1) Sample areas of 10-15 $mi.^2$ are selected which are expected to have high winter moose density, low moose density, and no moose at all.

2) Airplanes fly those areas for a fixed period of time, (4½ minutes per square mile) with a navigator and 2 spotters in each plane. The spotters note how many moose they see in each plot.

3) A helicopter flies very slowly (12 min/square mile) over part of some of the sample areas, counting how many moose are actually there.

4) A correction factor is established. For example, airplane spotters may see an average of 75% of the moose that a helicopter flight would see.

5) The airplane counts are corrected to estimate the actual number of moose on each plot.

6) An average number of moose per square mile is established for each stratum (high density, low density, no moose)

7) We measure on the maps how much of the 12,000 mile area is in each stratum, multiply by the moose density per stratum, run some statistics and

8) Get a total moose population estimate.

Navigators will receive maps showing the sample units assigned to their plane; it will be their job to make sure the plane stays within the sample unit boundaries.

Each spotter will receive moose survey forms, and fill out the appropriate information.

Search Pattern:

How the plane covers an area depends on topography. On flat land, fly transects at ½ mile intervals, and keep the transects as short ~~as short~~ as possible (go across a thin sample unit, rather than lengthwise.)

Mark the location of transects on a map, and the location of moose, if time permits. It will be helpful to have the transects pre-drawn on the map.

For hills and mountains, again keep a ½ mile interval between flight lines, but follow contours. Most of the observation can best be done on the downhill side of the plane. If the plane circles, the circles shouldn't be more than 1 mile across, and a series of slightly overlapping circles should be flown.

Recording Observations:

Attached is a blank survey form and an example form

1) Sample Unit Number - as shown on your map

2) Date

3) Start and stop time of the survey

4) Page

5) Location - not needed

6) Weather

7) Habitat description:
   - shrubland
   - subalpine (small trees at the treeline)
   - alpine (snow & rock)
   - forest with abundant undergrowth
   - mainly deciduous forest (trees without leaves)
   - mainly coniferous forest (pine, spruce, etc)

8) Snow conditions
   - fresh, moderate, or old (make your best guess)
   - cover - snow everywhere
     - some shrubs uncovered
     - bare spots showing
     - fresh snow on trees and shrubs

9) Habitat in which the moose are found.
   What kind of area is each observed moose in?
   Categories are:

   a) H = herbs, fields
   b) LS = Low shrubs, less than 6' high
   c) TS = Tall shrubs, more than 6' high
   d) D = Deciduous forest (Aspen, birch)
   e) SS = Sparse spruce forest; scattered coniferous trees
   f) S = Thick spruce forest
   g) P = Pine forest

10) Moose seen
   Use the UNIDENT column unless you see antlers, or a big moose with a smaller one (cow with calf).
   Use one line for each group of moose seen.
   (Single animal, one line; 2 cows and a calf, one line; etc)

And that's all there is to it.

Thanks for the help.

B. van Drimmelen

APPENDIX B

Apple II Plus Program for Moose Inventory Calculations

```
]LIST

100  HOME
110 PR = 0
120  PRINT "        $$$ MOOSE INV
     ENTORY $$$"
130  PRINT : PRINT
140  PRINT "THIS PROGRAM IS A BAS
     IC TRANSLATION OF A PROGRAM
     ORIGINALLY PRODUCED FOR AN H
     .P. 97 BY THE ALASKA DEPT. O
     F FISH AND GAME"
150  PRINT
160  PRINT "REFERENCE: GASAWAY, W
     .C. ET. AL. 1984.  ESTIMATIN
     G MOOSE DEMOGRAPHY FROM AERI
     AL SURVEYS (DRAFT). ALASKA D
     EPT. OF FISH  AND GAME. 130
     0 COLLEGE ROAD, FAIRBANKS. A
     LASKA 99701"
170  PRINT
180  PRINT "CONVERSION OF THE ORI
     GINAL H.P. 97       PROGRAM T
     O APPLESOFT WAS PERFORMED BY
        JOHN P. THORNTON. AND ENH
     ANCED BY IAN W.HATTER. WILDL
     IFE BRANCH. VICTORIA.       B
     RITISH COLUMBIA
190  VTAB 22: PRINT "TO ENTER DAT
     A .....PRESS (RETURN)": INPUT
     " ";D$
200  DIM LO(35),HI(35),X(50),Y(50
     ),Z(50),A(10),N(10)
210  HOME : PRINT
220  PRINT "YOU MAY ENTER DATA IN
      EITHER OF THE     FOLLOWING
      WAYS:
        1. FROM THE KEYBOARD
                        2. FROM A PRE
     VIOUSLY SAVED FILE"
230  PRINT : PRINT : INPUT "WHICH
      MODE OF DATA ENTRY (1 OR 2)
     ? ";A$
240 A$ =  LEFT$ (A$,1)
250  IF A$ = "1" OR A$ = "X" THEN
      GOTO 300
260  INPUT "NAME OF TEXT FILE TO
     BE USED? ";N$
270 D$ =  CHR$ (4)
280  PRINT D$;"OPEN";N$: PRINT D$
     ;"READ";N$: INPUT M: INPUT M
     M: FOR I = 1 TO M: INPUT Z(I
     ),Y(I),X(I): NEXT : PRINT D$
     ;"CLOSE";N$
290  GOTO 421
300  PRINT : INPUT "ENTER THE NUM
     BER OF S.U.'S SAMPLED: ";M
310  PRINT : PRINT "ENTER STRATA
     NO. (Z), NUMBER OF MOOSE  O
     BSERVED IN S.U. (Y), AND SIZ
     E OF S.U.  (X)"
320  PRINT : PRINT "TO CORRECT AN
      ERROR AFTER DATA ENTRY....T
     YPE (E)"
330  PRINT
340  FOR I = 1 TO M
350  PRINT "ENTER Z,Y,X FOR DATA
     ";I;: INPUT ": ";Z$,Y$,X$
360  IF  LEFT$ (Z$,1) <  > "E" OR
      LEFT$ (X$,1) <  > "E" OR  LEFT$
     (Y$,1) <  > "E" THEN  GOTO 3
     80
370 I = I - 1: PRINT " ": GOTO 35
     0
380 Z(I) =  VAL (Z$)
390 Y(I) =  VAL (Y$)
400 X(I) =  VAL (X$)
410 MM = Z(I)
420  NEXT I
421  PRINT
422  PRINT : INPUT "DO YOU WANT T
     O REVIEW THE DATA? (Y/N) ";A
     $
424  IF A$ = "Y" THEN  GOSUB 2900

430  PRINT : INPUT "DO YOU NEED T
     O CORRECT ANY OF THE DATA? (
     Y/N) ";A$
440  IF A$ = "Y" THEN  GOSUB 2700

450  PRINT : INPUT "DO YOU WANT T
     O ADD MORE DATA TO FILE?  (
     Y/N) ";A$
460  IF A$ = "Y" THEN  GOSUB 8500

470  PRINT
480 A = 0:N = 0:AS = 0:TT = 0:CTT
      = 0:DN = 0
490  HOME
500  FOR I = 1 TO MM
510  PRINT "TOTAL SURFACE AREA FO
     R STRATUM ";I;: INPUT ": ";A
     (I)
520  PRINT "TOTAL NO. S.U'S IN ST
     RATUM ";I;: INPUT ": ";N(I)
530 A = A + A(I):N = N + N(I)
540  PRINT
550  NEXT I
560  GOSUB 9000: REM  LOAD T TABL
     E
570  FOR I = 1 TO MM
580  HOME
590  GOSUB 1770: REM  SUM OF SQUA
     RES
600  GOSUB 1960: REM  MEAN AND VA
     RIANCE
610  HOME : PRINT  TAB( 3);"$$ SU
     MMARY TABLE FOR STRATUM ";I;
     " $$"
620  PRINT : PRINT "SURFACE AREA
     FOR STRATUM= ";A(I);" KM2"
630  PRINT "TOTAL NUMBER OF S.U.'
     S IN STRATUM= ";N(I)
```

```
640  PRINT "NUMBER OF S.U.'S SAMP
     LED= ";SS
650  PRINT "MEAN S.U. AREA= ";XME
     AN;" KM2"
660  PRINT "% OF STRATUM SAMPLED=
      ";((XMEAN * SS) / A(I)) * 1
     00
670  PRINT : PRINT "POPULATION ES
     TIMATE= ";T(I)
680  PRINT "MOOSE/KM2= ";T(I) / A
     (I)
690  PRINT : PRINT "VARIANCE OF E
     STIMATE=  ";VT
700  PRINT "SAMPLE VARIANCE = ";V
     AR
710  PRINT "% COEFFICIENT OF VARI
     ATION= "; SQR (VT) / T(I) *
     100
720  PRINT "RELATIVE VARIATION FA
     CTOR= ";RVF(I)
730  PRINT : PRINT : PRINT : PRINT

740  IF PF = 1 THEN  GOTO 760
750  INPUT "TO CONTINUE....PRESS
     <RETURN>";D$
760  NEXT I
770  HOME
780  PRINT  TAB( 7);"*** POPULATI
     ON SUMMARY ***"
790  PRINT
800  PRINT "TOTAL SURFACE AREA= "
     ;A
810  PRINT "TOTAL NUMBER OF S.U.'
     S= ";N
820  PRINT "TOTAL NUMBER OF S.U.'
     S SAMPLED= ";M
830  PRINT "% OF AREA SAMPLED= ";
     AS / A * 100
840  PRINT
850  PRINT "TOTAL POPULATION ESTI
     MATE= ";TT
860  PRINT "MOOSE/KM2= ";TT / A
870  PRINT : PRINT "VARIANCE OF E
     STIMATE= ";SVT
880  PRINT "% COEFFICIENT OF VARI
     ATION= "; SQR (SVT) / TT * 1
     00
890  GOSUB 2200: REM  DF AND CL
900  GOSUB 2460: REM  SCF
905  GOSUB 8000: REM  SCF
907  GOSUB 8900: REM  OPTIMAL ALL
     OCATION
910  IF PR = 1 GOTO 1060
915  PRINT
920  INPUT "DO YOU WANT TO SAVE D
     ATA ON A DISK FILE?(Y/N): ";
     A$
930  IF A$ = "Y" THEN  GOSUB 2760

935  PRINT

940  INPUT "DO YOU WANT A PRINT-O
     UT OF THE RESULTS? (Y/N): ";
     A$
950  IF A$ = "N" THEN  GOTO 1050
960  PRINT  CHR$ (4);"PR#1"
970  HOME
980  INPUT "TITLE: ";J$
990  PRINT : INPUT "DATE OF SURVE
     Y: ";A$
1000  INPUT "TODAY'S DATE: ";P$
1010 TT = 0:SVT = 0:DN = 0:AS = 0

1020  PRINT : PRINT
1030 PR = 1: GOSUB 2900
1040  GOTO 570
1050  PRINT : PRINT  TAB( 10);"TI
     ME FOR A COOL BREW !!!!!"
1060  END
1770  REM  CALCULATE SUMS Y, Y2,
     X, X2 AND XY
1780 SY = 0
1790 SX = 0
1800 YSUMSQ = 0
1810 XSUMSQ = 0
1820 XYSUM = 0
1830 NUM = 0
1840 SS = 0
1850  FOR J = 1 TO M
1860  IF Z(J) <  > I THEN  GOTO 1
     940
1870 SS = SS + 1
1880 SY = SY + Y(J)
1890 SX = SX + X(J)
1900 YSUMSQ = YSUMSQ + (Y(J) * Y(
     J))
1910 XSUMSQ = XSUMSQ + (X(J) * X(
     J))
1920 XYSUM = XYSUM + (Y(J) * X(J)
     )
1930 NUM = NUM + 1
1940  NEXT J
1950  RETURN
1960  REM  CALCULATE R, T-HAT, V(
     R) AND V(T-HAT)
1970 R = 0
1980 T = 0
1990 RSQ = 0
2000 VAR = 0
2010 RECIMSQ = 0
2020 VT = 0
2030 VR = 0
2040 R = SY / SX
2050 T(I) = R * A(I)
2060 RSQ = R ^ 2
2070 V1 = 2 * R * XYSUM
2080 V2 = RSQ * XSUMSQ
2090 VAR = (YSUMSQ - V1 + V2) / (
     NUM - 1)
2100 XMEAN = SX / NUM
2110 AS = AS + XMEAN * SS
```

```
2120 RECXMSD = 1 / (XMEAN ^ 2)
2130 VR = (RECXMSD * (VAR / NUM) *
     (1 - (NUM / N(I))))
2140 VT = (A(I) ^ 2) * VR
2150 TT = TT + T(I)
2160 SVT = SVT + VT
2170 DN(I) = ((VT ^ 2) / (NUM - 1
     ))
2175 DN = DN + DN(I)
2180 RVF(I) = (A(I) / XMEAN) * SQR
     (VAR)
2190  RETURN
2200  REM  CALCULATE DEGREEE OF F
     REEDOM (DF) AND CONFIDENCE L
     EVEL (CL)
2220 DF = ((SVT ^ 2) / DN) + .5
2230 DF =  INT (DF)
2240  IF (30 < DF AND DF <  = 35)
     THEN DF = 30
2250  IF (35 < DF AND DF <  = 50)
     THEN DF = 31
2260  IF (50 < DF AND DF <  = 90)
     THEN DF = 32
2270  IF (90 < DF AND DF <  = 180
     ) THEN DF = 33
2280  IF (DF > 180) THEN DF = 34
2285 J = DF
2290  IF PR = 1 GOTO 2310
2300  INPUT "ENTER 90 OR 95 AS A
     CONFIDENCE LEVEL.      ";CI
2310  PRINT
2320  IF CI = 90 THEN TV = LO(J)
2330  IF CI = 95 THEN TV = HI(J)
2370  PRINT "DEGREES OF FREEDOM (
     DF)= ";DF
2380  PRINT "CONFIDENCE LEVEL (CL
     )= ";CI;" %"
2390  PRINT "T-VALUE=";LO(J)
2400 CU = TT + ((LO(J)) * ( SQR (
     SVT)))
2410 CL = TT - ((LO(J)) * ( SQR (
     SVT)))
2420 CE = ((TT - CL) / TT) * 100
2430  PRINT "UPPER CONFIDENCE LEV
     EL=";CU,"LOWER CONFIDENCE LE
     VEL=";CL
2440  PRINT "CL AS A % OF ESTIMAT
     E= ";CE
2450  RETURN
2460  REM   SIGHTABILITY CORRECTI
     ON FACTOR (SCF)
2490  PRINT
2500  IF PR = 1 AND V$ = "Y" GOTO
     2642
2510  IF PR = 1 GOTO 1060
2520  INPUT "DO YOU WISH TO APPLY
      A SIGHTABILITY     CORRECTI
     ON FACTOR? (Y/N) ";V$
2530  IF V$ = "N" THEN  RETURN
2540  HOME : PRINT  TAB( 3);"###
     SIGHTABILITY CORRECTION FACT
     OR ###"
2550  PRINT
2641  GOSUB 3020
2642 U = 0:V = 0:UV = 0:V2 = 0:U2
      = 0
2644  FOR I = 1 TO N
2646 U = U + U(I)
2648 V = V + V(I)
2650 V2 = V2 + V(I) ^ 2
2652 U2 = U2 + U(I) ^ 2
2654 UV = UV + U(I) * V(I)
2656  NEXT I
2658 S2UV = (UV / (N - 1)) - ((U *
     V) / (N * (N - 1)))
2660 S = (V2 / (N - 1)) - ((V ^ 2
     ) / (N * (N - 1)))
2662 SCF = (U / V) + (N * S2UV /
     V ^ 2) - ((N * U * S) / V ^
     3)
2664 SDS = (U2 - (2 * SCF * UV) +
     (SCF ^ 2 * V2)) / (N - 1)
2666 VSCF = (N / (V ^ 2)) * SDS
2669  PRINT
2680  PRINT : PRINT
2690  RETURN
2695  REM  ERROR CORRECTION
2700  INPUT " WHICH DATA POINT NU
     MBER TO CHANGE? ";AN
2710  IF AN > M THEN  PRINT "":: PRINT
     "THAT NUMBER DOESN'T EXIST I
     N YOUR FILE. TRY AGAIN.": GOTO
     2700
2720  PRINT "ENTER NEW VALUES FOR
      DATA POINT NUMBER ";AN:: INPUT
     Z(AN),Y(AN),X(AN)
2730  INPUT "MORE CORRECTIONS? (Y
     /N) ";AN$
2740  IF  LEFT$ (AN$,1) = "Y" THEN
     2700
2750  RETURN
2760  PRINT : INPUT "ENTER NAME O
     F NEW DISK FILE. ";N$: REM
     STORE DATA ON DISK
2770 D$ =  CHR$ (4)
2780  PRINT D$;"MON C,I,O"
2790  PRINT D$;"OPEN "N$
2800  PRINT D$;"DELETE"N$
2810  PRINT D$;"OPEN"N$
2820  PRINT D$;"WRITE "N$
2830  PRINT M
2840  PRINT MM
2850  FOR I = 1 TO M
2860  PRINT Z(I);",";Y(I);",";X(I
     )
2870  NEXT I
2880  PRINT D$;"CLOSE "N$
2890  HOME : RETURN
2900  REM  REVIEW DATA
2910  HOME : PRINT  TAB( 13);"DAT
     A SUMMARY"
2920  PRINT
2930  PRINT "STRATA"; TAB( 15);"M
     OOSE"; TAB( 30);"S.U. SIZE"
```

```
2940  PRINT  TAB( 32):"(KM2)
2950  PRINT
2960  FOR I = 1 TO M
2970  PRINT  TAB( 3);Z(I); TAB( 1
     6);Y(I); TAB( 32);X(I)
2980  NEXT I
2990  IF PR = 1 GOTO 3010
3000  PRINT : INPUT "TO CONTINUE.
     ....PRESS <RETURN>";D$
3010  PRINT : PRINT : HOME : RETURN

3020  DIM U(50),V(50)
3030  PRINT "YOU MAY ENTER DATA I
     N EITHER OF THE     FOLLOWIN
     G WAYS:
             1. FROM THE KEYBOAR
     D                    2. FROM
      A PREVIOUSLY SAVED FILE."
3040  PRINT : PRINT : INPUT "WHIC
     H MODE OF DATA ENTRY (1 OR 2
     )? ";A$
3050 A$ =  LEFT$ (A$,1)
3060  IF A$ = "1" OR A$ = "K" THEN
      GOTO 3110
3070  INPUT "NAME OF TEXT FILE TO
      BE USED? ";N$
3080 D$ =  CHR$ (4)
3090  PRINT D$;"OPEN";N$: PRINT D
     $;"READ";N$: INPUT N: FOR I =
     1 TO N: INPUT V(I),U(I): NEXT
     : PRINT D$;"CLOSE";N$
3100  RETURN
3110  PRINT : INPUT "ENTER THE NU
     MBER OF DATA POINTS TO BE
     FITTED  ";N
3120  HOME
3130  PRINT "NOW ENTER THE DATA P
     OINTS. FIRST THE    STANDARD
     IZED COUNT (S), THEN THE HIG
     H    INTENSITY COUNT (I)."
3140  PRINT : PRINT "TO CORRECT A
     N ERROR AFTER DATA ENTRY....
     .........TYPE (E)."
3160  PRINT
3170  FOR I = 1 TO N
3180  PRINT "ENTER S,I DATA POINT
      NUMBER ";I;: INPUT " ";V$,U
     $
3190  IF  LEFT$ (U$,1) <  > "E" OR
      LEFT$ (V$,1) <  > "E" THEN
      GOTO 3210
3200 I = I - 1: PRINT " ": GOTO 3
     180
3210 U(I) =  VAL (U$)
3220 V(I) =  VAL (V$)
3230  NEXT I
3240  PRINT : INPUT "DO YOU NEED
     TO CORRECT ANY OF THE DATA
     ? ";A$
3250  IF  LEFT$ (A$,1) = "Y" THEN
      GOSUB 6000
3260  INPUT "DO YOU WISH TO SAVE
      DATA TO DISK? ";A$
3270  IF A$ = "Y" THEN  GOSUB 700
     0
3280  RETURN
5995  REM  ERROR CORRECTION
6000  INPUT " WHICH DATA POINT NU
     MBER TO CHANGE? ";AN
6005  IF AN > N THEN  PRINT "":: PRINT
      "THAT NUMBER DOESN'T EXIST I
     N YOUR FILE. TRY AGAIN.": GOTO
      6000
6010  PRINT "ENTER NEW STANDARD A
     ND INTENSIVE VALUES FOR PLOT
      NUMBER ";AN;: INPUT V(AN),U
     (AN)
6020  INPUT "MORE CORRECTIONS? (Y
     /N) ";AN$
6030  IF  LEFT$ (AN$,1) = "Y" THEN
      6000
6040  RETURN
6995  REM  STORE DATA ON DISK
7000  PRINT : INPUT "ENTER NAME O
     F NEW DISK FILE. ";N$
7010 D$ =  CHR$ (4)
7015  PRINT D$:"MON C,I,O"
7020  PRINT D$;"OPEN "N$
7025  PRINT D$:"DELETE"N$
7027  PRINT D$;"OPEN"N$
7030  PRINT D$;"WRITE "N$
7040  PRINT N
7050  FOR I = 1 TO N
7060  PRINT V(I);",";U(I)
7070  NEXT
7080  PRINT D$;"CLOSE "N$
7090  RETURN
7095  REM  SIGHTABILITY CORRECTIO
     N FACTOR
8000  HOME : PRINT  TAB( 3);"###
     SIGHTABILITY CORRECTION FACT
     OR ###"
8002  PRINT
8005  PRINT "SIGHTABILITY CORRECT
     ION FACTOR= "; INT (SCF * 10
     000 + .5) / 10000
8010  PRINT "VARIANCE OF SCF= ";V
     SCF
8040 CTT = SCF * TT
8050 VEE = (SCF ^ 2 * SVT) + (TT ^
     2 * VSCF) + (VSCF * SVT)
8060 DOF = N - 1
8070  IF DOF < DF THEN DF = DOF
8075  PRINT
8077  IF PR = 1 GOTO 8090
8080  INPUT "ENTER CORRECTION FAC
     TOR FOR MOOSE MISSEDDURING H
     IGH INTENSITY SEARCHES: ";CF

8085  PRINT
8090 CTT = CTT * CF
8100 VEE = VEE * CF ^ 2
```

```
8105 J = DF
8110  PRINT "CORRECTED MOOSE ESTI
     MATE= ";CTT
8120  PRINT "CORRECTED VARIANCE=
     ";VEE
8130  PRINT "DEGREES OF FREEDOM=
     ";DF
8140  PRINT "CONFIDENCE LEVEL= ";
     CL;" %"
8150  PRINT "T-VALUE= ";LO(J)
8160 CU = CTT + LO(J) * ( SQR (VE
     E))
8170 CL = CTT - LO(J) * ( SQR (VE
     E))
8180 CE = ((CTT - CL) / CTT) * 10
     0
8190  PRINT "UPPER CONFIDENCE LEV
     EL= ";CU,"LOWER CONFIDENCE L
     EVEL= ";CL
8200  PRINT "CL AS A % OF ESTIMAT
     E= ";CE
8202  PRINT : PRINT
8203  IF PR = 1 GOTO 8206
8205  INPUT "TO CONTINUE.....PRES
     S <RETURN>";D$
8206  PRINT : PRINT : RETURN
8210  RETURN
8500  REM  ADD NEW DATA
8505  HOME
8510 II = M + 1
8515  PRINT : INPUT "ENTER THE NO
     . OF NEW S.U.'S SAMPLED: ";M
     N:M = M + MN
8520  PRINT : PRINT "ENTER STRATM
      NO. (Z), NUMBER OF MOOSE
     OBSERVED IN S.U. (Y), AND SI
     ZE OF S.U.  (X)"
8525  PRINT : PRINT "TO CORRECT A
     N ERROR AFTER DATA ENTRY....
     TYPE(E)"
8530  PRINT
8535  FOR I = II TO M
8537  PRINT "ENTER Z,Y,X FOR DATA
      ";I;: INPUT ";Z$,Y$,X$
8540  IF  LEFT$ (Z$,1) <  > "E" OR
      LEFT$ (X$,1) <  > "E" OR  LEFT$
     (Y$,1) <  > "E" THEN  GOTO 8
     550
8545 I = I - 1: PRINT " ": GOTO 8
     535
8550 Z(I) =  VAL (Z$)
8555 Y(I) =  VAL (Y$)
8560 X(I) =  VAL (X$)
8565 MM = Z(I)
8570  NEXT I
8899  REM  OPTIMAL ALLOCATION
8900  HOME : PRINT  TAB( 7);"$$$
     OPTIMAL ALLOCATION $$$"
8902  IF PR = 1 GOTO 8908
8904  PRINT : PRINT
8906  INPUT "DO YOU WANT OPTIMAL
     ALLOCATION (Y/N)? ";DA$
8908  IF DA$ = "N" THEN  RETURN
8910 SUM = 0
8912  PRINT
8914  IF PR = 1 THEN  PRINT "TOTA
     L NO. OF SU'S TO BE SAMPLED=
      ";NA: GOTO 8918
8916  INPUT "TOTAL NO. OF SU'S TO
      BE SAMPLED= ";NA
8918  IF RVF(1) = 0 THEN RVF(1) =
     .0000001
8920  FOR II = 2 TO MM:SUM = SUM +
     RVF(II) / RVF(1): NEXT II
8922 NL = NA / (1 + SUM)
8924  PRINT
8926  FOR II = 1 TO MM
8928  PRINT "OPTIMAL NO. OF SU'S
     IN STRATUM ";II;"= "; INT (N
     L * RVF(II) / RVF(1) + .5)
8930  NEXT II
8932  PRINT
8934  RETURN
9000  REM  LOAD T-TABLE VALUES FO
     R 90% (LO) AND 95% (HI) CONF
     IDENCE LIMITS
9010 LO(1) = 6.314
9020 LO(2) = 2.920
9030 LO(3) = 2.353
9040 LO(4) = 2.132
9050 LO(5) = 2.015
9060 LO(6) = 1.943
9070 LO(7) = 1.895
9080 LO(8) = 1.860
9090 LO(9) = 1.833
9100 LO(10) = 1.812
9110 LO(11) = 1.796
9120 LO(12) = 1.782
9130 LO(13) = 1.771
9140 LO(14) = 1.761
9150 LO(15) = 1.753
9160 LO(16) = 1.746
9170 LO(17) = 1.740
9180 LO(18) = 1.734
9190 LO(19) = 1.729
9200 LO(20) = 1.725
9210 LO(21) = 1.721
9220 LO(22) = 1.717
9230 LO(23) = 1.714
9240 LO(24) = 1.711
9250 LO(25) = 1.708
9260 LO(26) = 1.706
9270 LO(27) = 1.703
9280 LO(28) = 1.701
9290 LO(29) = 1.699
9300 LO(30) = 1.697
9310 LO(31) = 1.684
9320 LO(32) = 1.671
9330 LO(33) = 1.658
9340 LO(34) = 1.645
9350 HI(1) = 12.706
9360 HI(2) = 4.303
9370 HI(3) = 3.182
9380 HI(4) = 2.776
```

```
9390 HI(5) = 2.571
9400 HI(6) = 2.447
9410 HI(7) = 2.365
9420 HI(8) = 2.306
9430 HI(9) = 2.262
9440 HI(10) = 2.228
9450 HI(11) = 2.201
9460 HI(12) = 2.179
9470 HI(13) = 2.160
9480 HI(14) = 2.145
9490 HI(15) = 2.131
9500 HI(16) = 2.120
9510 HI(17) = 2.110
9520 HI(18) = 2.101
9530 HI(19) = 2.093
9540 HI(20) = 2.086
9550 HI(21) = 2.080
9560 HI(22) = 2.074
9570 HI(23) = 2.069
9580 HI(24) = 2.064
9590 HI(25) = 2.060
9600 HI(26) = 2.056
9610 HI(27) = 2.052
9620 HI(28) = 2.048
9630 HI(29) = 2.045
9640 HI(30) = 2.042
9650 HI(31) = 2.021
9660 HI(32) = 2.000
9670 HI(33) = 1.980
9680 HI(34) = 1.960
9690  RETURN
```

APPENDIX C

Example of Run of Moose
Inventory Program Using
Southeastern Skeena Data

TITLE: 1983 S.E. SKEENA MOOSE SURVEY

DATE OF SURVEY: FEB 28 - MARCH 4, 1983

TODAY'S DATE: MAY 23, 1985

DATA SUMMARY

STRATA	MOOSE	S.U. SIZE (KM2)
1	9	39
1	5	28
1	9	34
1	9	39
1	10	41
1	24	36
1	70	36
1	23	23
1	50	39
1	16	39
1	25	36
1	10	31
1	13	23
1	26	39
1	17	18
1	57	49
1	19	28
1	5	34
1	18	34
1	6	26
1	23	47
1	46	44
2	5	31
2	6	39
2	3	39
2	1	26
2	5	39
2	12	34
2	6	41
2	1	44
2	7	36
2	10	26
2	2	31
3	1	54
3	1	28
3	0	39
3	0	44
3	0	62

SUMMARY TABLE FOR STRATUM 1

SURFACE AREA FOR STRATUM= 2900 KM2
TOTAL NUMBER OF S.U.'S IN STRATUM= 81
NUMBER OF S.U.'S SAMPLED= 22
MEAN S.U. AREA= 34.681818182 KM2
% OF STRATUM SAMPLED= 26.310344B

POPULATION ESTIMATE= 1873.78768
MOOSE/KM2= .646133683

VARIANCE OF ESTIMATE= 64024.3068
SAMPLE VARIANCE = 276.572052
% COEFFICIENT OF VARIATION= 13.503e777
RELATIVE VARIATION FACTOR= 1390.59379

SUMMARY TABLE FOR STRATUM 2

SURFACE AREA FOR STRATUM= 3791 KM2
TOTAL NUMBER OF S.U.'S IN STRATUM= 108
NUMBER OF S.U.'S SAMPLED= 10
MEAN S.U. AREA= 35.5 KM2
% OF STRATUM SAMPLED= 9.36428383

POPULATION ESTIMATE= 598.016901
MOOSE/KM2= .15774e479

VARIANCE OF ESTIMATE= 15753.3207
SAMPLE VARIANCE = 15.223655
% COEFFICIENT OF VARIATION= 20.9880746
RELATIVE VARIATION FACTOR= 41e.6e2963

SUMMARY TABLE FOR STRATUM 3

SURFACE AREA FOR STRATUM= 6265 KM2
TOTAL NUMBER OF S.U.'S IN STRATUM= 166
NUMBER OF S.U.'S SAMPLED= 6
MEAN S.U. AREA= 43 KM2
% OF STRATUM SAMPLED= 4.11811652

POPULATION ESTIMATE= 97.131783
MOOSE/KM2= .015503876

VARIANCE OF ESTIMATE= 3007.83042
SAMPLE VARIANCE = .882038339
% COEFFICIENT OF VARIATION= 56.4631773
RELATIVE VARIATION FACTOR= 136.834734

POPULATION SUMMARY

TOTAL SURFACE AREA= 12956
TOTAL NUMBER OF S.U.'S= 19
TOTAL NUMBER OF S.U.'S SAMPLED= 38
% OF AREA SAMPLED= 10.6205619

TOTAL POPULATION ESTIMATE= 2568.93636
MOOSE/KM2= .198281596

VARIANCE OF ESTIMATE= 82785.4579
% COEFFICIENT OF VARIATION= 11.2001459

DEGREES OF FREEDOM (DF)= 30
CONFIDENCE LEVEL (CL)= 90 %
T-VALUE=1.697
UPPER CONFIDENCE LEVEL=3057.20505
LOWER CONFIDENCE LEVEL=2080.6[illegible]
CL AS A % OF ESTIMATE= 19.0066477

SIGHTABILITY CORRECTION FACTOR

SIGHTABILITY CORRECTION FACTOR= 2.2804
VARIANCE OF SCF= .146811763

CORRECTED MOOSE ESTIMATE= 6385.44624
CORRECTED VARIANCE= 1677041.3
DEGREES OF FREEDOM= 18
CONFIDENCE LEVEL= 90 %
T-VALUE= 1.734
UPPER CONFIDENCE LEVEL= 8630.98[illegible]
LOWER CONFIDENCE LEVEL= 4139.90[illegible]
CL AS A % OF ESTIMATE= 35.1665465

OPTIMAL ALLOCATION

]

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Wildlife Working Reports should not be cited because of the preliminary nature of the data they contain.

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WR-12 1983 Southeastern Skeena regional moose abundance and composition survey. B. van Drimmelen. June 1985. 47pp.